

Contemporary Management of Renal Trauma

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In the management of renal trauma, surgical exploration inevitably leads to nephrectomy in all but a few specialized centers. With current management options, the majority of hemodynamically stable patients with renal injuries can be successfully managed nonoperatively. Improved radiographic techniques and the development of a validated renal injury scoring system have led to improved staging of injury severity that is relatively easy to monitor. This article reviews a multidisciplinary approach to facilitate the care of patients with renal injury.

[Rev Urol. 2011;13(2):65-72 doi: 10.3909/riu0512]

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Key words: Renal injury • Nephrectomy • Blunt trauma • Angiogenesis • Embolization

Renal injury occurs in approximately 1% to 5% of all traumas^{1,2} and can be classified as blunt or penetrating according to the mechanism. Blunt injuries are usually secondary to high-energy collisions such as motor vehicle accidents (MVA), falls from a height, and contact sports, although significant injuries have been reported following trivial trauma in structurally abnormal kidneys. In the Australian state of Victoria,^a 89 Grade ≥ 2 renal injuries were recorded in 2008, with blunt trauma accounting for 94.4%; 57.3% were Grade 2 injuries, 12.4% Grade 3, 25.8% Grade 4, and 4.5% Grade 5. MVAs and motorcycle accidents were the most common cause of injury, accounting for 48.3% of all renal injuries.³ Civilian penetrating injuries are uncommon in Australia, and

^aEstimated population of 5.2 million as of 31 December 2007 (Australian Bureau of Statistics).

typically of low velocity, such as stabbings. In military series and certain urban areas (eg, South Africa and North America), gunshot wounds are a significant cause of penetrating injuries. The majority of blunt renal trauma cases are associated with injury to other abdominal organs, but they are commonly low-grade injuries.⁴

In the management of renal trauma, surgical exploration inevitably leads to nephrectomy in all but a few specialized centers. Given the success of conservative management of other solid organ injuries, this approach has been increasingly applied to patients with renal trauma. With current management, the majority of hemodynamically stable patients with renal injuries are successfully managed nonoperatively.^{5,6} Improved radiographic techniques and the development of a validated renal injury scoring system have led to improved staging of injury severity that is relatively easy to monitor. In addition, improved hemodynamic management of patients in specialized units has led to improved outcomes with nonoperative management.

Furthermore, selective treatment with interventional procedures in radiology has reduced the need for surgical intervention. Successful hemostasis with angiography and renal embolization has been achieved for patients with blunt and penetrating renal injuries.^{2,7,8}

Initial Management

Resuscitation

The approach to management of patients with major abdominal trauma has been standardized according to set protocols with the development of structured advanced trauma life support (ATLS) guidelines, the development of policies for minimizing coagulopathy with massive transfusions,

and the use of damage control surgery (DCS).

Initial management of an adult with major trauma or suspected renal injury follows ATLS guidelines. The principles of ATLS are to identify and treat the immediate life-threatening injuries first by the assessment of Airway, Breathing, Circulation, Disability, Exposure/Environment. Renal injuries may present in the primary survey as hypovolemic shock; however, most will be identified in the secondary survey after imaging.

The development of massive transfusion protocols in resuscitation has seen significant reductions in 24-hour mortality. They aim to reduce traumatic coagulopathy through the administration of fresh frozen plasma, platelets, and coagulation products, in addition to packed red blood cells.

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sive massive transfusion protocols, with a ratio of 1:1:1 of RBCs, fresh frozen plasma, and platelets.¹¹ Although there is a higher proportion of penetrating trauma in these populations, early evidence suggests that similar protocols may also be associated with improvements in early mortality and coagulopathy in civilian settings.¹²⁻¹⁴

DCS involves a staged surgical approach to injury identification and repair to minimize extensive procedures on unstable patients.

DCS aims to reduce the lethal triad of acidosis, hypothermia, and coagulopathy by gaining early control of bleeding and contamination and preventing of further heat loss.

ministration of fresh frozen plasma, platelets, and coagulation products, in addition to packed red blood cells (RBCs). At our institution, the protocol is activated on the release of 4 or more units of RBCs and/or anticipated massive transfusion.⁹ Products are replaced at a ratio of 4 units of RBCs to 2 units of fresh frozen plasma. Platelets are used to maintain levels greater than $50 \times 10^9/L$ and the international normalized ratio is kept less than 2.0. Cryoprecipitate is considered if fibrinogen is less than 1.0 g/L.

Evidence regarding the effect of blood product ratio on mortality outcomes differs.¹⁰ Recent military experiences in Iraq and Afghanistan have seen the development of more aggres-

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However, a recent systematic review has questioned the benefit of such an approach.¹⁵

Grade

The Injury Severity Scale for the kidney is an anatomic-based description, developed by the American Association for the Surgery of Trauma (AAST) in 1989 to facilitate clinical research (Table 1), and it has been validated for clinical use.¹⁶ It classifies renal injuries into five grades in order of increasing severity. It is widely used and is a powerful predictor of clinical outcome.^{17,18} The grade directly correlates with the need for intervention, nephrectomy, dialysis, and mortality.^{17,19,20} Consequently, an

Table 1
Kidney Injury Scale

Grade	Description
1	Contusion or nonexpanding subcapsular hematoma without parenchymal laceration
2	Nonexpanding perirenal hematoma or laceration < 1 cm deep without urinary extravasation
3	Laceration > 1 cm deep without urinary extravasation
4	Laceration extending through renal cortex into collecting system or segmental renal artery or vein injury with contained hemorrhage or partial vessel laceration or vessel thrombosis
5	Shattered kidney or renal pedicle injury/avulsion of renal hilum

accurate early assessment of grade is vital to determine management strategy. Figures 1 through 5 illustrate examples of each grade.

Investigation

The majority of renal injuries are associated with injury of other abdominal organs. In the event of suspected blunt renal injury, the indications for

imaging are visible hematuria, microscopic hematuria with systolic blood pressure < 90 mm Hg, the presence of major associated injuries, or a high index of suspicion based on mechanism of injury, such as a rapid deceleration injury.²¹ It is important to note that absence of hematuria does not exclude renal injury. Renal imaging should be performed in all patients

with penetrating trauma to the torso where renal injury is suspected on the basis of entry or exit wounds.²

Ultrasound is routinely performed at the bedside in trauma patients as part of focused assessment by sonography in trauma to identify hemoperitoneum. It has a low sensitivity for the identification of retroperitoneal free fluid.²²

Computed tomography (CT) is the gold standard for visceral imaging after blunt trauma.²³ The arterial and portal venous phase can identify active extravasation, whereas delayed phase images assess the renal collecting system and ureteric continuity.²⁴

If the patient progresses to emergency laparotomy without undergoing a CT scan, and a renal injury is identified, then a one-shot intravenous pyelogram can be performed at the time of surgery (using 2 mL/kg intravenous [IV] contrast).² This not only assesses the degree of renal injury, but also confirms the presence of a functioning contralateral kidney.

Management

The Stable Patient

Patients with Grades 1 through 4 injuries can generally be managed conservatively. It is important, however, to appreciate that there are significant clinical differences between a Grade 4 laceration and a Grade 4 unstable vascular injury, and that the latter may necessitate intervention. Grade 5

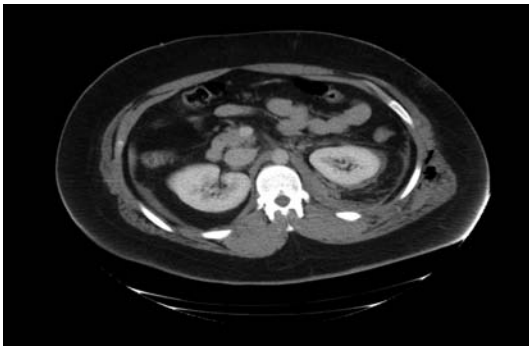


Figure 1. Grade 1 injury.

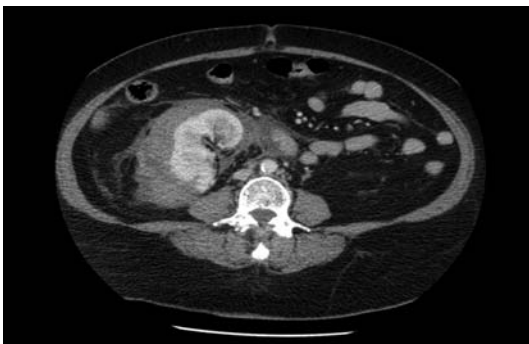


Figure 2. Grade 2 injury.

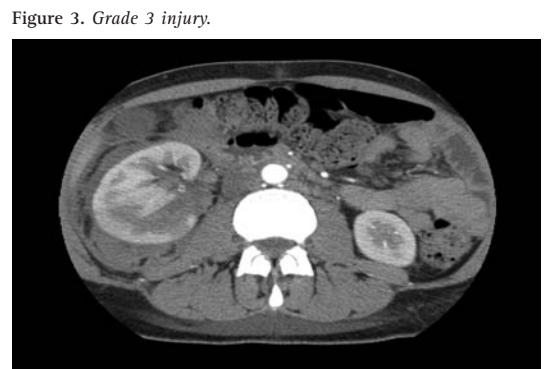


Figure 3. Grade 3 injury.

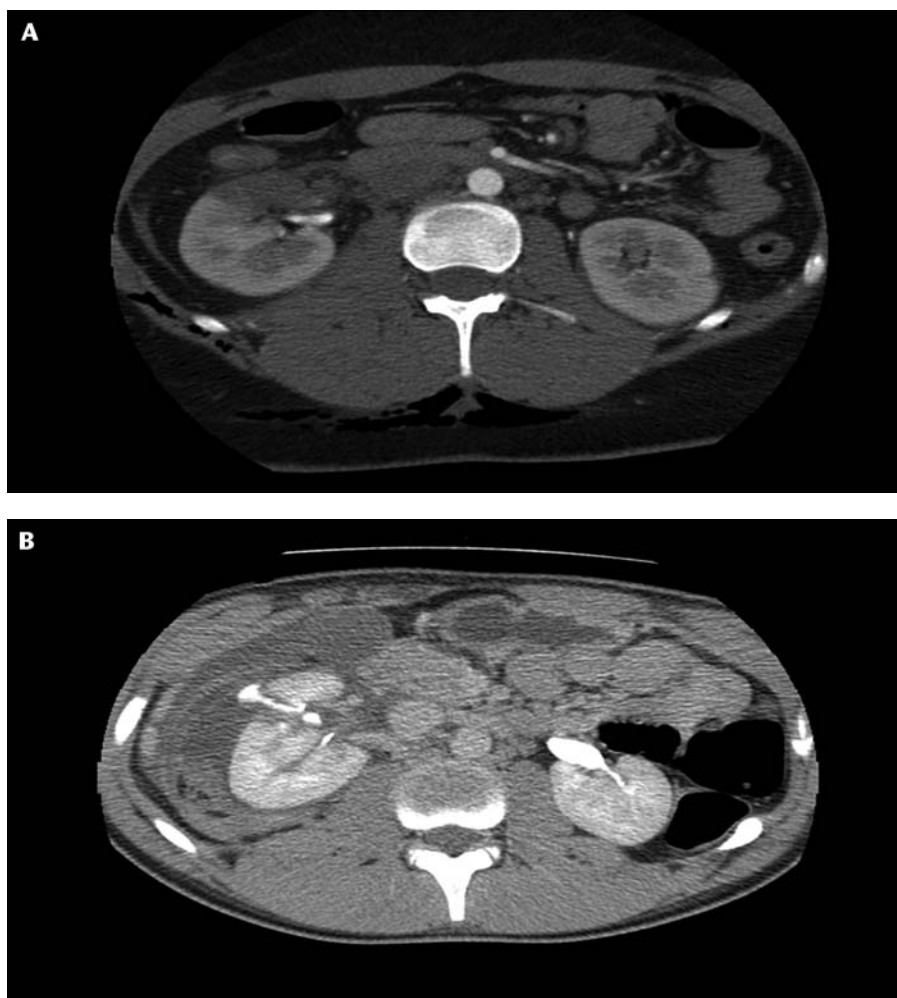


Figure 4. (A) Grade 4 injury with segmental renal injury. (B) Grade 4 injury with urine extravasation.

injuries are more controversial, as traditional treatment involves intervention and possibly nephrectomy. However, successful conservative management has been reported and it is important to understand that there is a spectrum of Grade 5 injuries from the less severe (avascular kidneys with minimal hematoma) to more severe (burst kidney or uncontained pedicle avulsion).

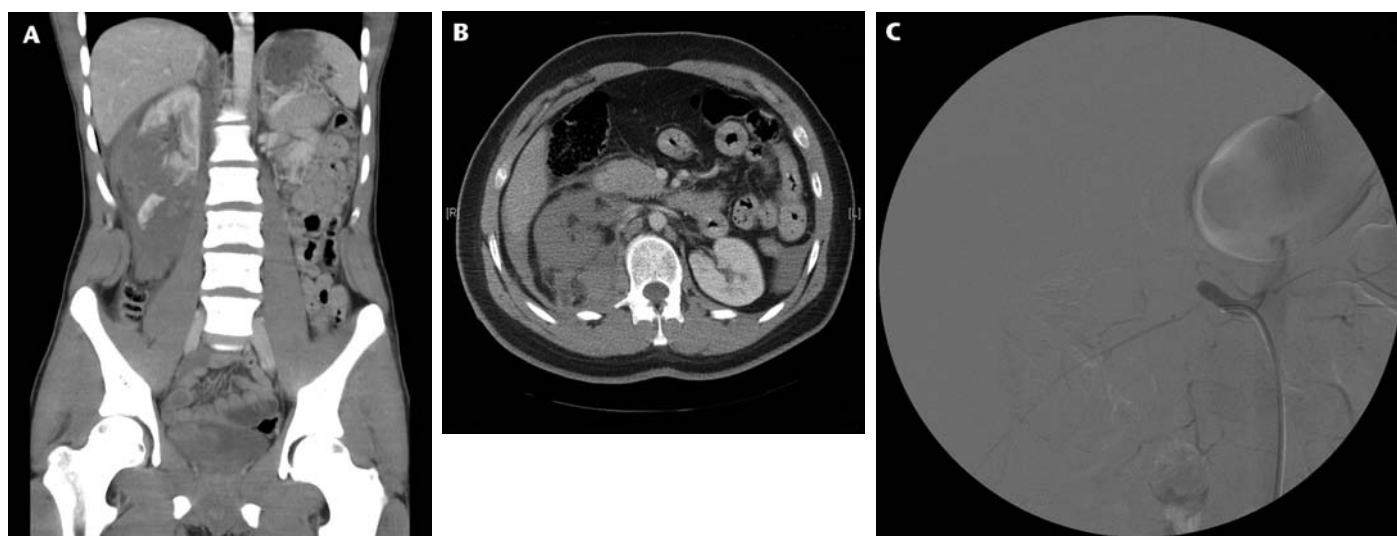
Previously, exploratory laparotomy was recommended for all patients with penetrating renal injuries. However, nonoperative management has become more accepted for Grades 1 through 3 with penetrating renal injuries in the absence of associated intra-abdominal injury or hemodynamic instability.^{21,25}

The Unstable Patient

Patients will often have significant concomitant injuries and will require operative intervention for those injuries (eg, pelvic stabilization, splenectomy, abdominal packing). Thus, care is often directed by specific trauma surgeons.

Indications for exploration in renal trauma are life-threatening hemorrhage, renal pedicle avulsion, or

Figure 5. (A) Grade 5 injury, shattered kidney. (B) Grade 5 injury with devascularized kidney. (C) Angiogram of Grade 5 injury with devascularized kidney.



pulsatile/expanding retroperitoneal hematoma at the time of laparotomy.^{6,25} In cases of active extravasation of IV contrast, the decision of whether to undergo surgical exploration or angioembolization must be based on the presence of concomitant injuries and the experience of the surgical team and radiologists. It is our experience that these injuries are now managed with embolization. Although injured kidneys may be salvaged in expert hands by gaining proximal vascular control and kidney reconstruction, patient safety is paramount and the usual result is nephrectomy. Vascular repair has been described in patients with a solitary kidney or bilateral injury, but it corresponds with poor outcomes and increased complication rates.²⁵

The role of angiography and selective renal embolization in renal trauma is increasing and is an alternative treatment to laparotomy in patients who do not require immediate surgery.² Successful hemostasis has been reported in Grade 4 injuries caused by both blunt and penetrating mechanisms. It has been associated with a 94.4% success rate in selected patients with blunt renal artery trauma of Grade 4 or 5.⁸ It is associated with reduced renal parenchymal injury and complications when compared with surgical management.²⁶

Subsequent Management

Conservative management involves close reassessment and observation with serial estimations of hematocrit, initially twice daily. The patient should be kept to strict bed rest until the hematuria resolves. The role of antibiotics is not clear, but IV broad spectrum antibiotics should be used if there is suggestion of damage to the collecting system and urine leak.

Repeat abdominal CT imaging with a delayed phase is recommended between 36 and 72 hours after initial

injury for Grades 3 through 5 blunt renal injury. For more minor grades of injury, repeat imaging is probably unnecessary.²⁷⁻²⁹ We have evaluated the role of further repeat imaging after this time at our institution and found that it adds little if the patient remains stable.²⁷ Thus, it is reasonable to repeat the imaging only if there is a change in the patient's condition.

Complications

Urinary Extravasation

Urinoma formation (Figure 6) is the most common complication, occurring in 1% to 7% of all patients with renal trauma.³⁰ Clinically, the devel-

opment of sepsis or declining renal function raises suspicion of urinoma formation, which may be confirmed via CT.

Urinary extravasation resolves spontaneously in 76% to 87% of cases.^{6,28} Intervention may be required if there is a persistent leak or urine collection. The insertion of a retrograde stent or percutaneous nephrostomy typically aids resolution.³¹ Percutaneous drainage of the urinoma is rarely necessary.

Infection

Perinephric abscesses (Figure 7) and infected urinomas may develop



Figure 6. Urinoma formation after a Grade 5 injury.



Figure 7. Perinephric abscess after a Grade 4 injury.

secondary to bacterial seeding or concomitant enteric or pancreatic injury. Management with percutaneous drainage is often successful, although open drainage of multiloculated collections is sometimes required.⁵

Delayed Hemorrhage

Delayed hemorrhage is a common complication with deep lacerations of the renal cortex and medulla and is seen commonly in penetrating renal trauma, particularly stab injuries.^{6,28} Clinically, these patients may present with hematuria, falling hematocrit, or hemodynamic instability. It is often associated with pseudoaneurysm (Figure 8) or arteriovenous fistula

formation. Delayed hemorrhage occurs in 13% to 25% of Grade 3 or 4 renal injuries that are managed expectantly; however, most cases are successfully treated with angioembolization.^{28,32}

Devitalized Renal Segment

Injuries with nonviable renal segments can be managed conservatively; however, these injuries are associated with a higher complication rate and the need for delayed intervention.^{21,28} These patients require close monitoring.

Hypertension

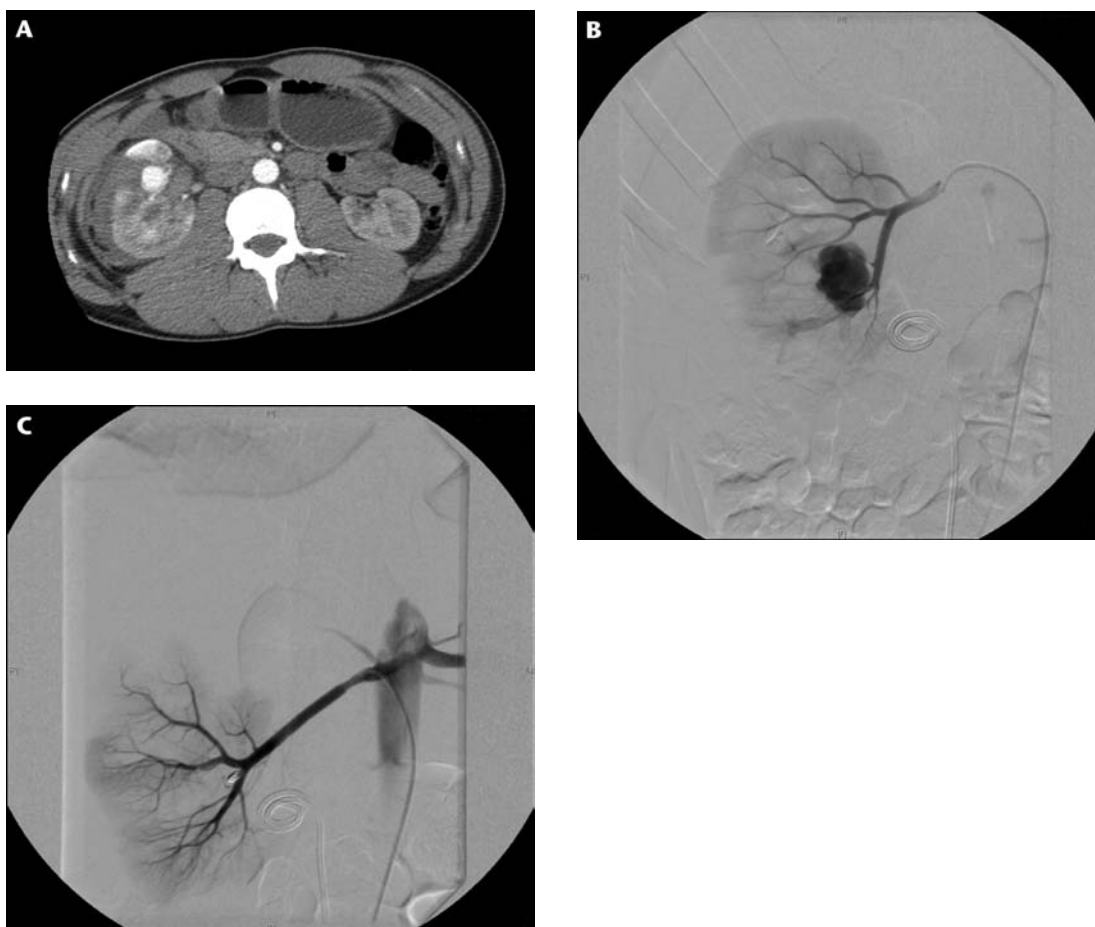
Injury to the renal artery or compression of the kidney from hematoma/

fibrosis is thought to lead to posttraumatic hypertension mediated by increased renin secretion in response to renal ischaemia. Incidence relates to the severity of renal injury, and patients with Grade 4 and 5 injuries should have periodic blood pressure monitoring in the long term. Nephrectomy is occasionally necessary to control renovascular hypertension refractory to medical management. Successful treatment with arterial stenosis repair or partial nephrectomy has been reported.²⁸

Renal Insufficiency

The risk of renal impairment will depend on preexisting renal disease,

Figure 8. (A) Pseudoaneurysm formation in a Grade 4 injury. (B) Angiogram of the same patient. (C) Angiogram of the same patient postembolization (note vasospasm in the proximal renal artery).



age, presence of single kidney, and associated multiorgan failure. One study showed the risk of requiring dialysis was 0.46% in a large review of all grades of renal trauma.¹⁹ The need for dialysis was associated with increasing AAST grade and age older than 40 years. If just high-grade injuries are analyzed, the risk may be as high as 6%.³³

Follow-Up

General recommendations include 3-month follow-up that comprises a physical examination, urinalysis, blood pressure measurement, and assessment of renal function.² There

will require individualized imaging to monitor and prevent related complications.

Conclusions

Renal injury may be a life-threatening event, but if handled correctly can be managed safely without the need for nephrectomy in most cases. Blunt trauma accounts for the majority of renal injuries, of which a greater proportion is a less severe injury grade. The majority of hemodynamically stable patients are successfully managed conservatively. Embolization is an alternative treatment option to control bleeding, particularly in pa-

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are few published data regarding the role of follow-up imaging. Some centers advocate renography as quantitative assessment of renal function following Grade 4 and 5 injuries.²⁸ Patients should have long-term monitoring for renovascular hypertension, especially those with high-grade injuries. Patients with concomitant injuries, such as colonic or pancreatic,

tients who do not require intervention for concomitant injuries. A multidisciplinary approach coordinated by trauma service specialists facilitates the care of these patients in our institution. ■

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Main Points

- In the management of renal trauma, surgical exploration typically leads to nephrectomy in all but a few specialized centers. Conservative management has been increasingly applied to patients with renal trauma due to the success this option has seen in handling other solid organ injuries.
- The organ Injury Severity Scale for the kidney classifies renal injuries into five grades in order of increasing severity. It is widely used and is a powerful predictor of clinical outcome. The grade directly correlates with the need for intervention, nephrectomy, dialysis, and mortality.
- The majority of renal injuries are associated with injury of other abdominal organs. In the event of suspected blunt renal injury, the indications for imaging are visible hematuria, microscopic hematuria with systolic blood pressure < 90 mm Hg, the presence of major associated injuries, or a high index of suspicion based on mechanism of injury, such as a rapid deceleration injury.
- Indications for exploration in renal trauma are life-threatening hemorrhage, renal pedicle avulsion, or pulsatile/expanding retroperitoneal hematoma at the time of laparotomy. In cases of active extravasation of intravenous contrast, surgical exploration or angioembolization must be based on the presence of concomitant injuries and the surgical team's experience.

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